CONTACT METAMORPHISM OF BITUMINOUS COAL BY INTRUDING DIKE IN THE ILLINOIS BASIN CAUSES SHORT-RANGE THERMAL ALTERATION

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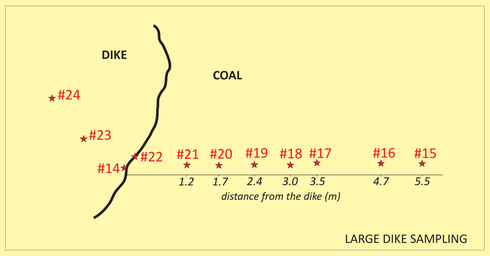
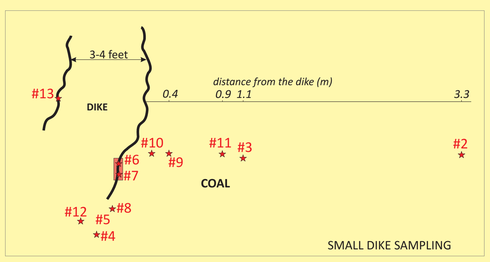
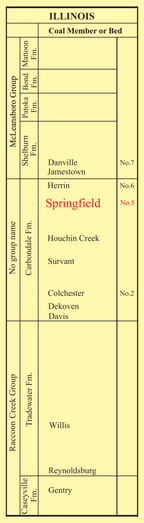
ABSTRACT

Changes in high-volatile bituminous coal (Pennsylvanian) near contacts with volcanic intrusions in Illinois were investigated with respect to coal chemistry, carbon and hydrogen stable isotope ratios, and pore structure. Vitrinite reflectance (Ro) increases from ~0.6% to ~5% within 4.7 m from the dike. Elemental chemistry of the coal shows distinct reduction in hydrogen and nitrogen content approaching the intrusions. No trend was noticed for total sulfur content, but decreases in sulfate and organic sulfur contents towards the dikes indicate thermal sulfur reduction (TSR). Carbon isotopic values did not show significant changes, whereas hydrogen isotopic values showed a distinct trend of becoming more negative toward the dikes. Contact metamorphism has a dramatic effect on coal porosity. The mesopore volume decreases from 0.01 cm^3/g in the unaffected coal to 0.004 cm^3/g at a distance of 4.5 m away from the contact, then hovers around 0.004 cm^3/g closer to the contact. In contrast, the micropore volume shows a progressive decrease from 0.04 cm^3/g in unaffected coal to almost 0.01 cm^3/g at the contact. Strongly decreasing mesopore and micropore volumes in the altered zone, together with frequent cleat and fracture-filling by calcite, indicate deteriorating conditions for both coalbed gas sorption and gas transmissibility.

SAMPLING



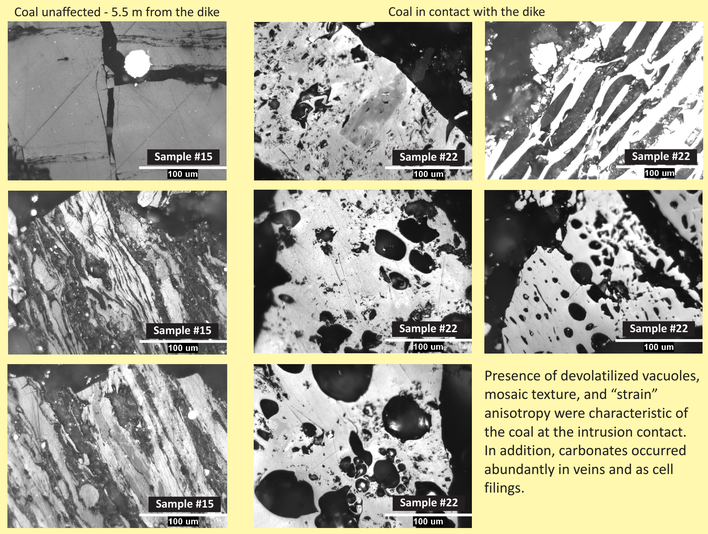




OPTICAL CHARACTERISTICS OF THE COAL

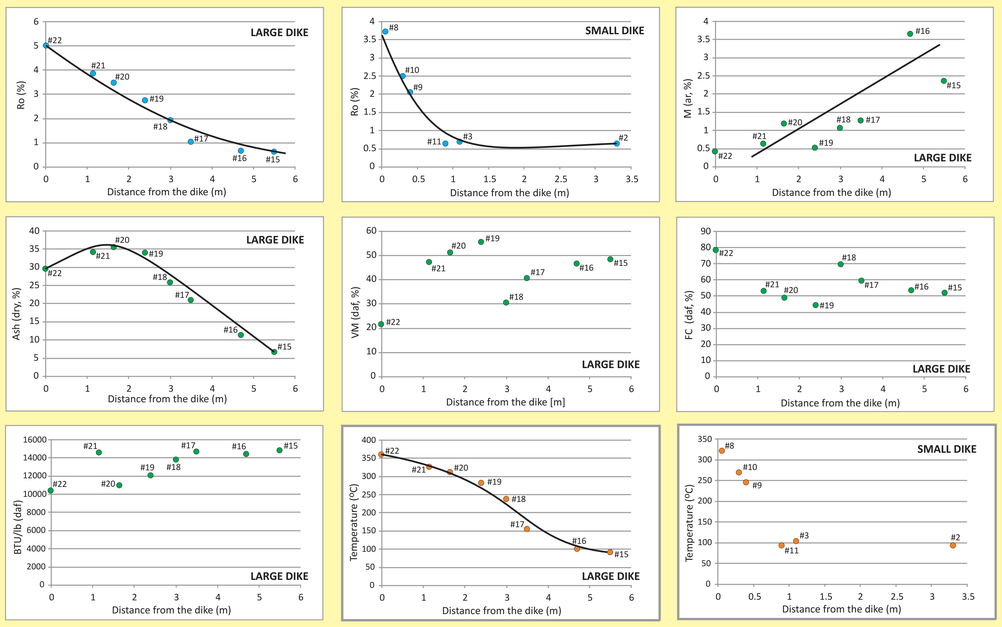
Coal unaffected - 5.5 m from the dike

Coal in contact with the dike



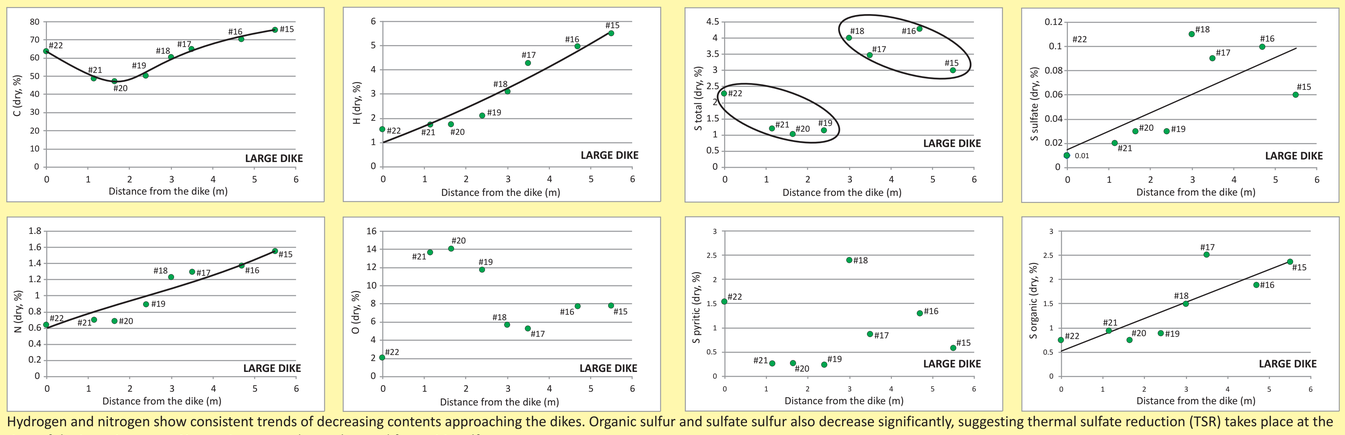
Presence of devolatilized vacuoles, mosaic texture, and "strain" anisotropy were characteristic of the coal at the intrusion contact. In addition, carbonates occurred abundantly in veins and as cell filings.

CHANGES IN COAL RANK



Vitrinite reflectance shows a progressive increase approaching the intrusions. The altered zone is ~1 m long around the small dike (~1 m thick) and ~4.7 m long around the large dike. The temperature of the intrusions was estimated at ~325 °C (small dike) and ~360 °C (large dike).

CHANGES IN COAL CHEMISTRY

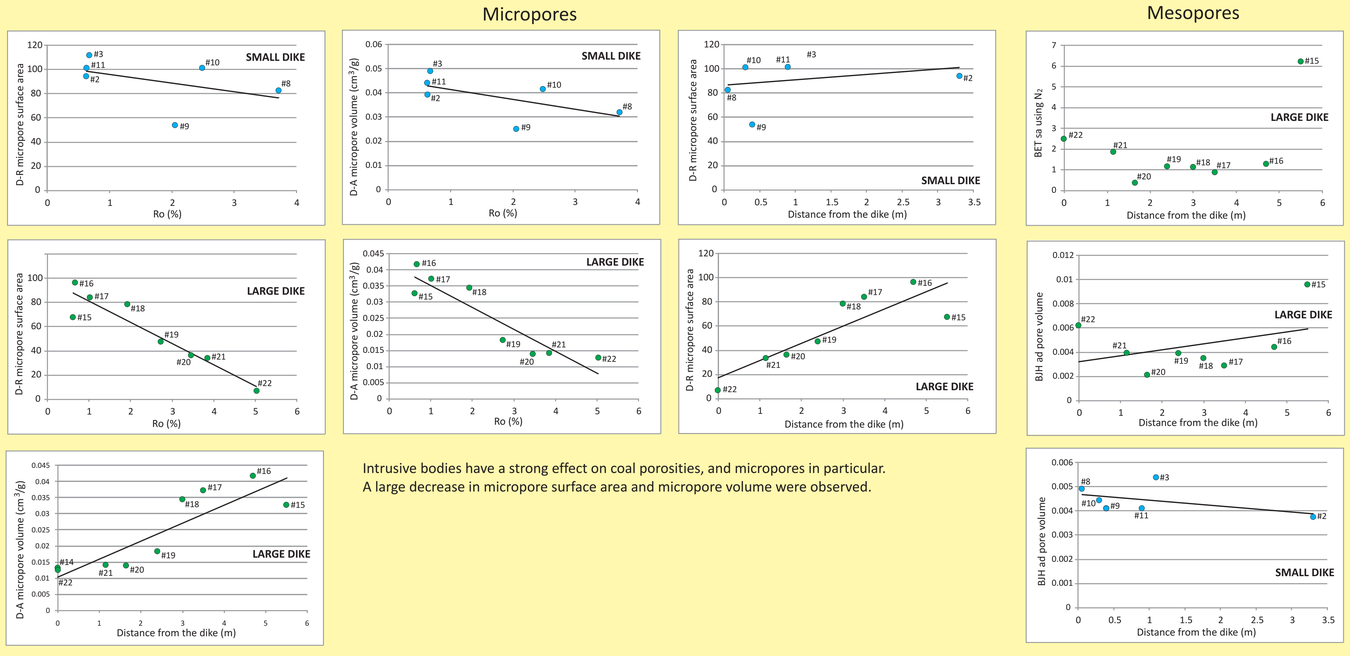


Hydrogen and nitrogen show consistent trends of decreasing contents approaching the dikes. Organic sulfur and sulfate sulfur also decrease significantly, suggesting thermal sulfate reduction (TSR) takes place at the time of the intrusive event. No consistent trend was observed for pyritic sulfur.

CHANGES IN PORE-SIZE DISTRIBUTION

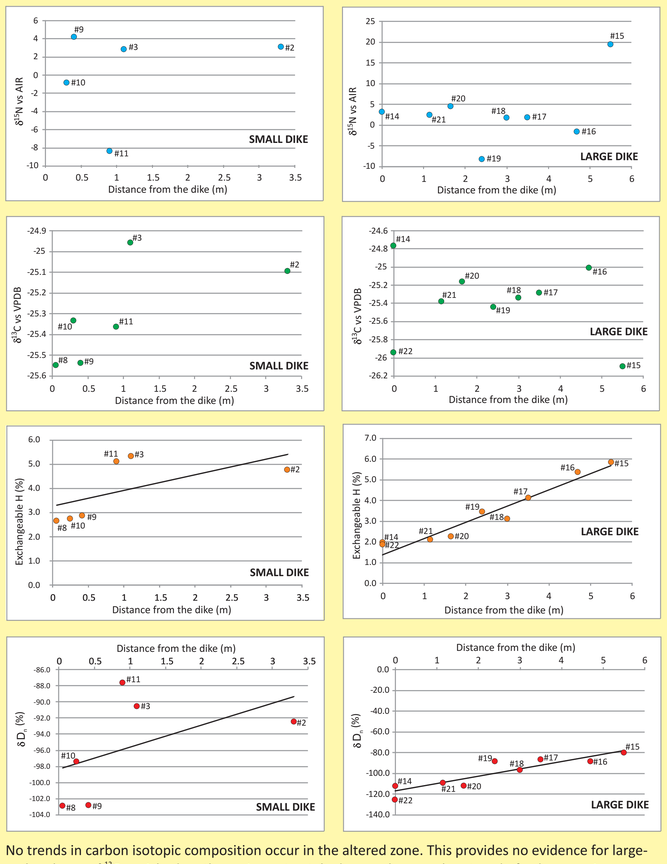
Micropores

Mesopores



Intrusive bodies have a strong effect on coal porosities, and micropores in particular. A large decrease in micropore surface area and micropore volume were observed.

CHANGES IN ISOTOPIC COMPOSITION



No trends in carbon isotopic composition occur in the altered zone. This provides no evidence for large-scale release of ^{12}C-enriched methane. In contrast, hydrogen shows a clear trend of a decrease in exchangeable H and hydrogen isotopic values becoming more negative.

CONCLUSIONS

1. The thermal effects occurring in the areas that surrounded the small and large dike differed. The lack of distinct trends around the small dike suggests short-term, localized heat and a long-term heating event in the area around the large dike.

2. The lack of carbon isotopic trends around the dike suggests that a minimal amount of ^{12}C-enriched methane was released, compared to a large amount of solid organic carbon of ^{13}C ~-25.4 ‰.

3. Hydrogen D/H ratios of non-exchangeable organic hydrogen in kerogen become more negative closer to the intrusion, indicating isotopic exchange with deuterium-depleted water, partly generated as a result of thermal sulfate reduction (TSR).

4. A significant increase in micropore volume and surface area affect gas adsorption capacities in the zones surrounding the dikes.